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[54] **FUEL INJECTION NOZZLE FOR INTERNAL COMBUSTION ENGINES**

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[51] **Int. Cl.**^{3} **F02M 61/08; F02M 61/16**

[52] **U.S. Cl.** **239/453;** 239/533.3; 239/533.12

[58] **Field of Search** 239/533.2–533.12, 239/453

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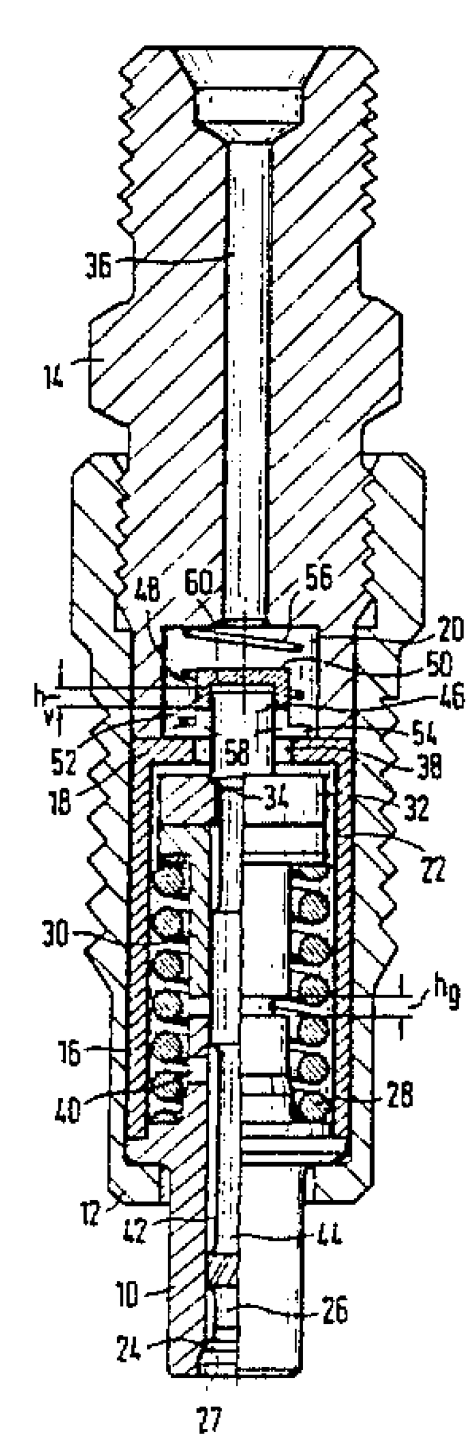
[57] **ABSTRACT**

A fuel injection nozzle for internal combustion engines, having a valve needle arranged to open toward the outside and said valve needle further connected with a piston which defines a fuel-filled damping chamber, which communicates with the flow path of the fuel only via a throttle conduit during the opening stroke of the valve needle. The damping chamber is formed in a cap which is placed onto the piston. As a result, jamming of the elements in the radial direction is avoided. Furthermore, the piston may be embodied by the valve needle per se, resulting in a simple and space-saving construction. By means of the appropriate embodiment and supporting of the cap, the damping effect can be limited dependent on the stroke and/or the travel speed of the valve needle.

10 Claims, 7 Drawing Figures



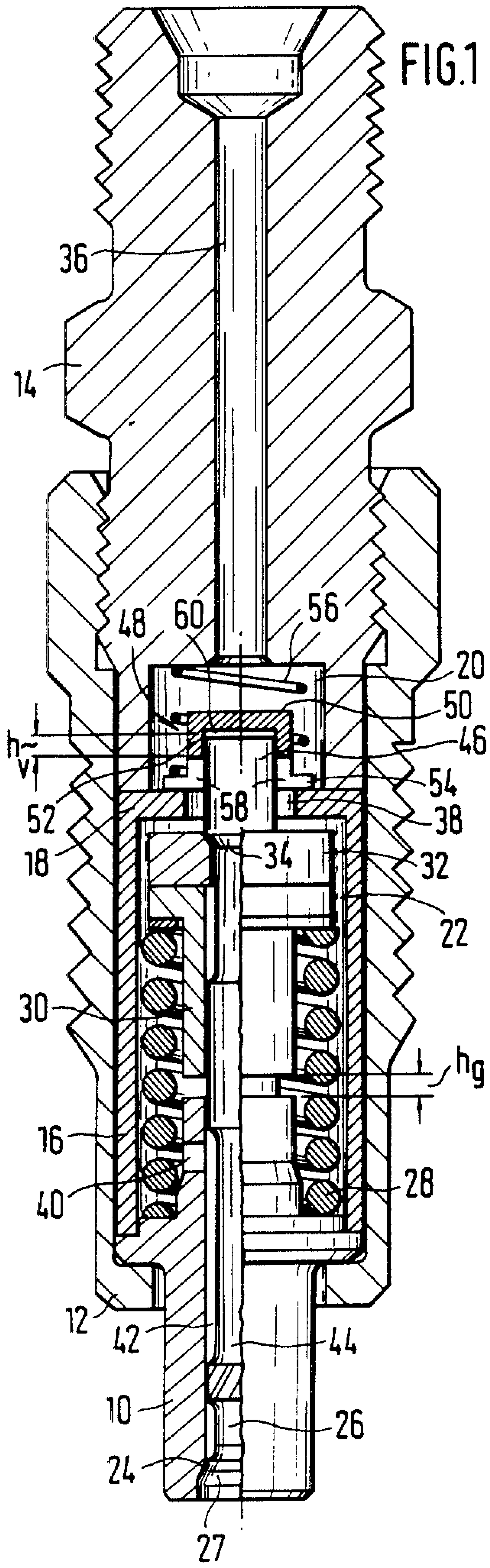


FIG.1

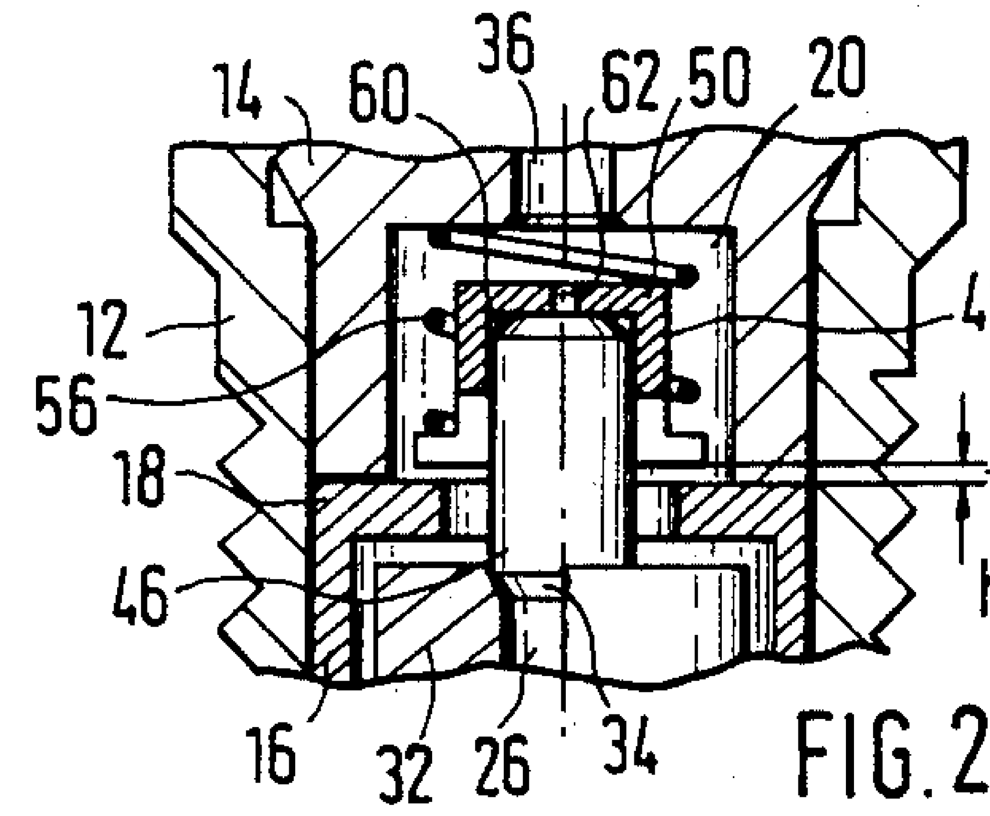


FIG.2

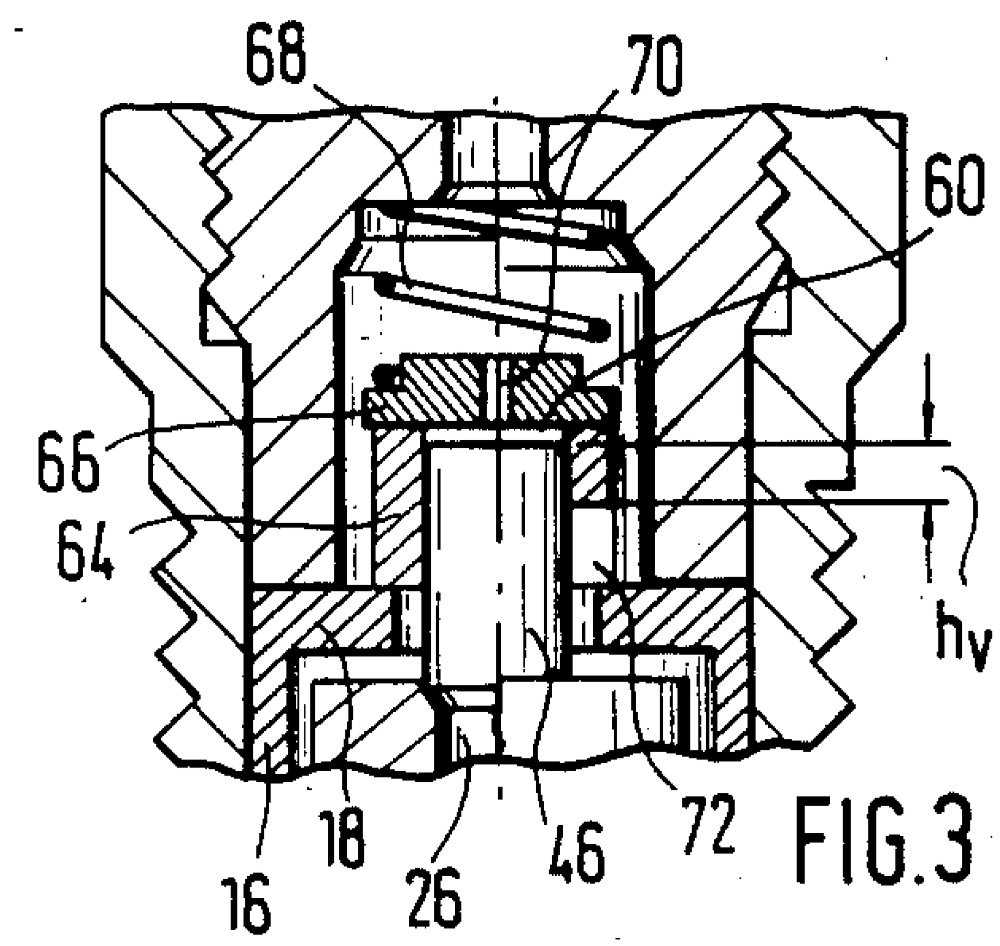


FIG.3

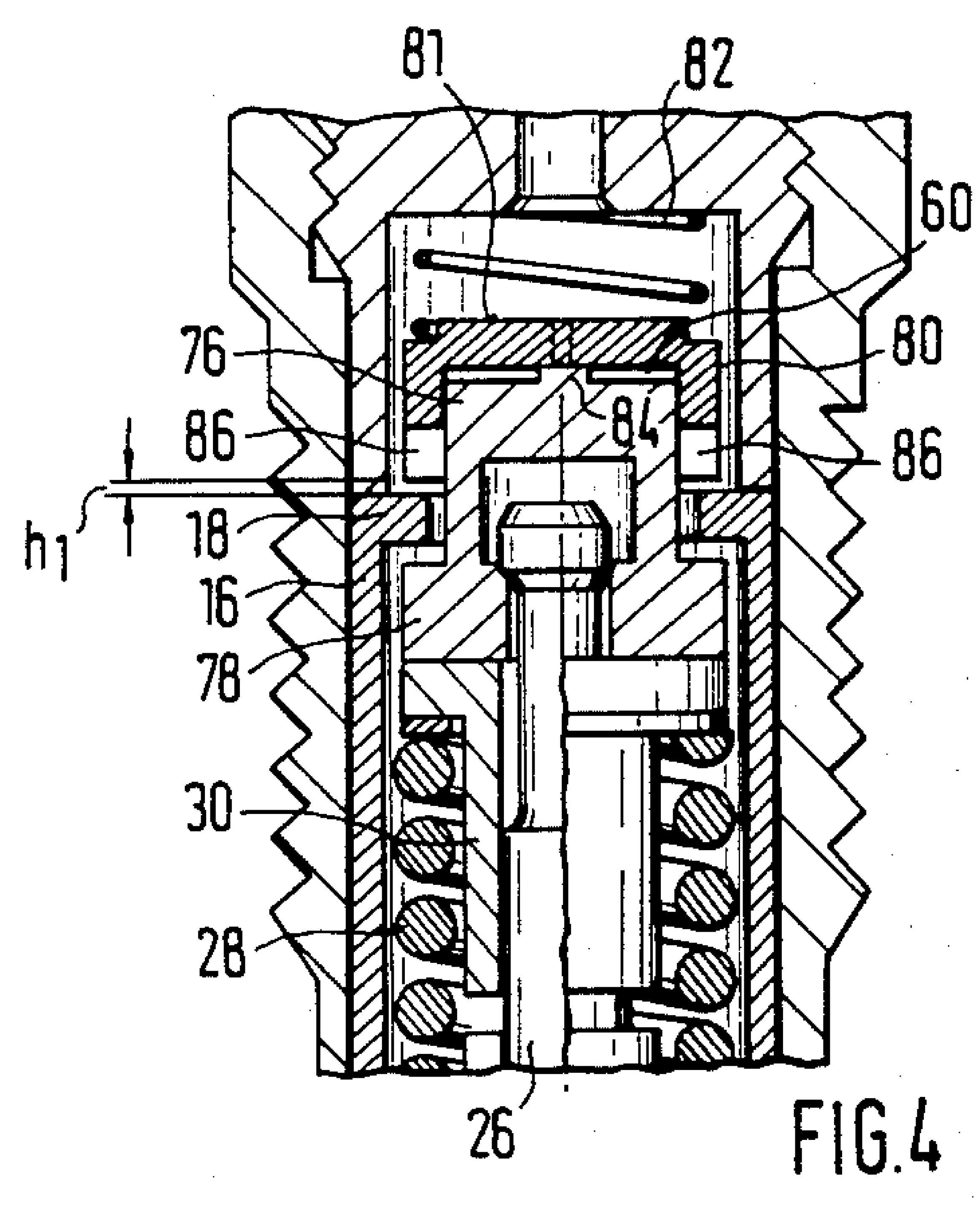


FIG.4

FIG. 5

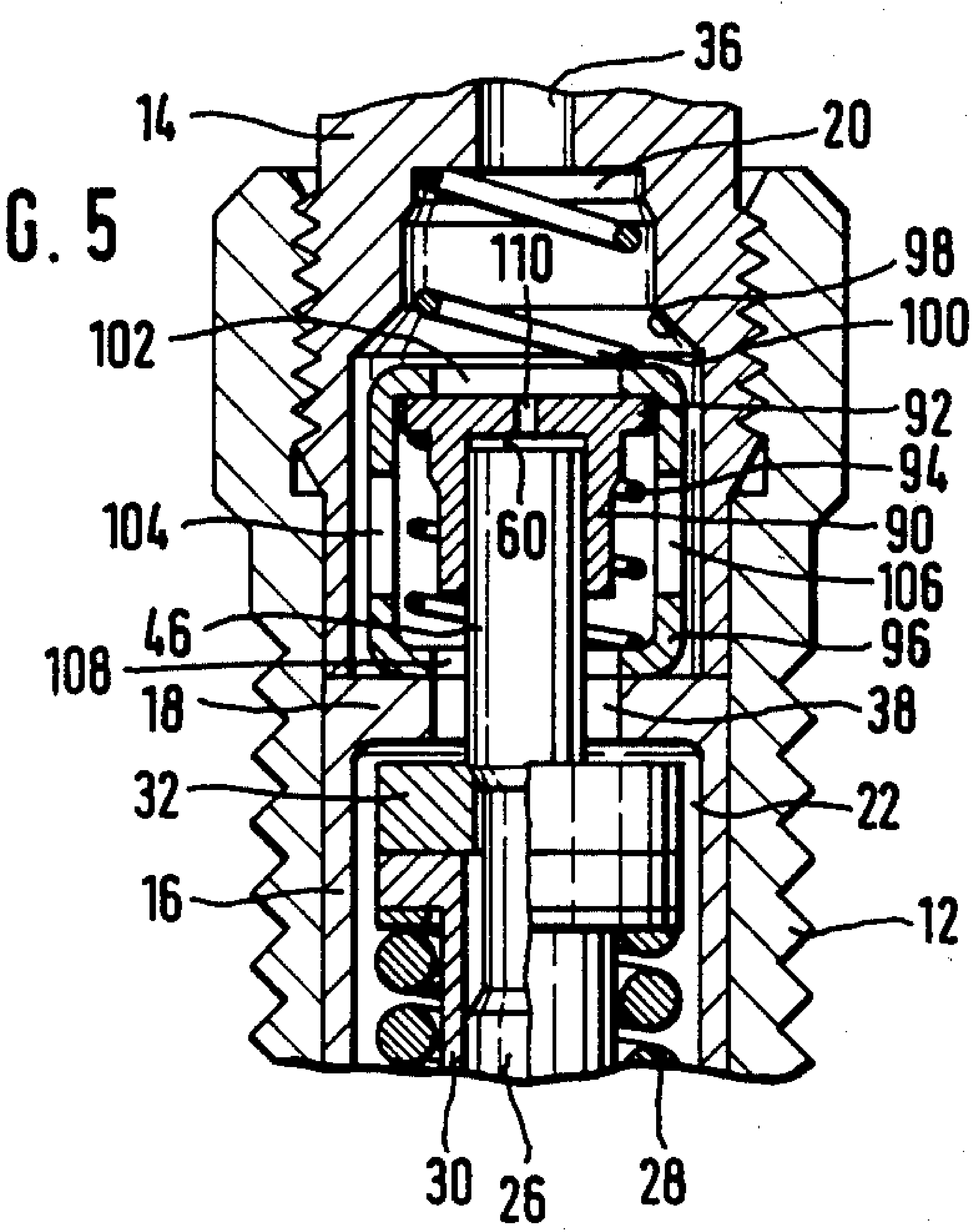


FIG. 6

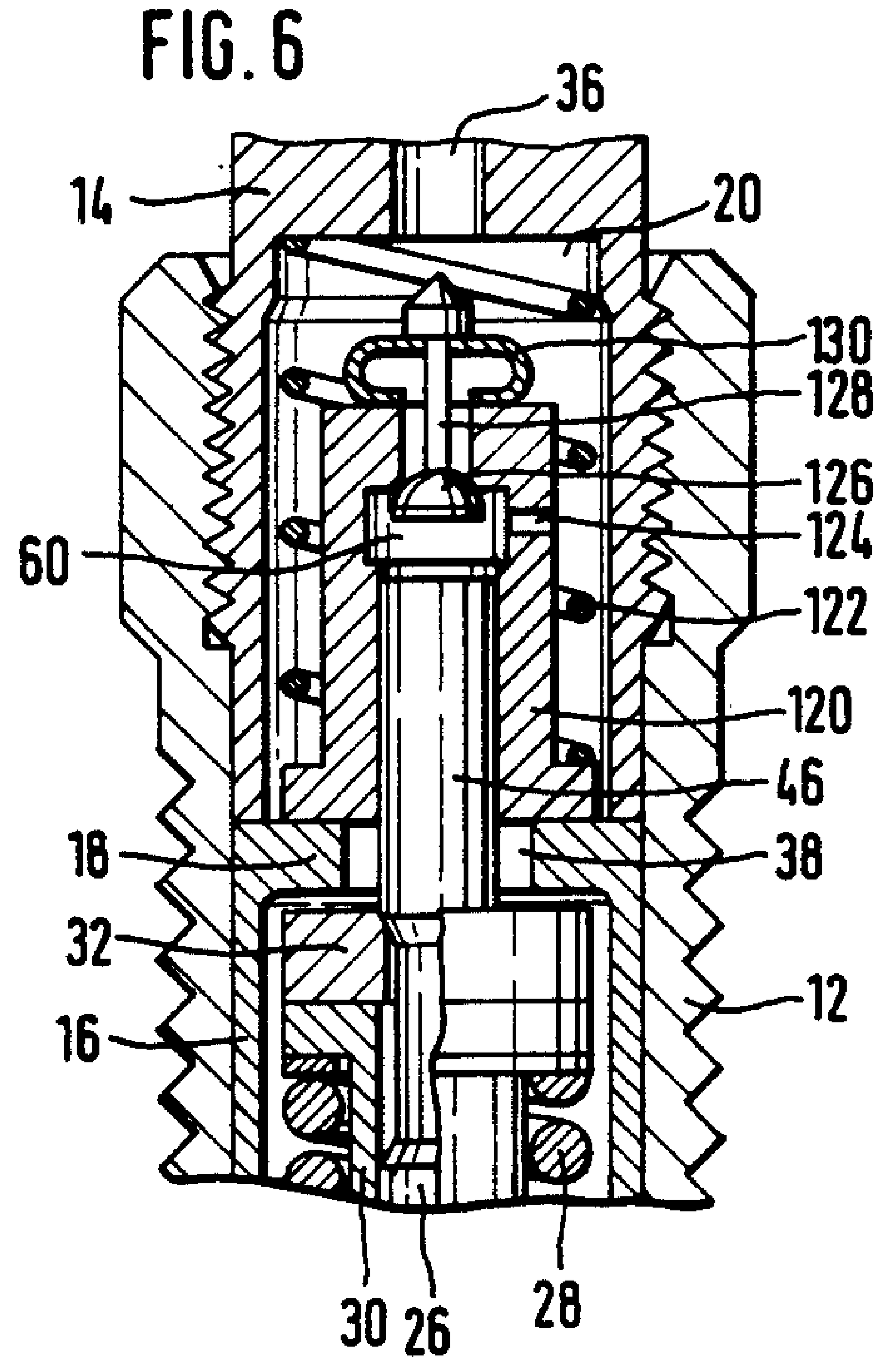
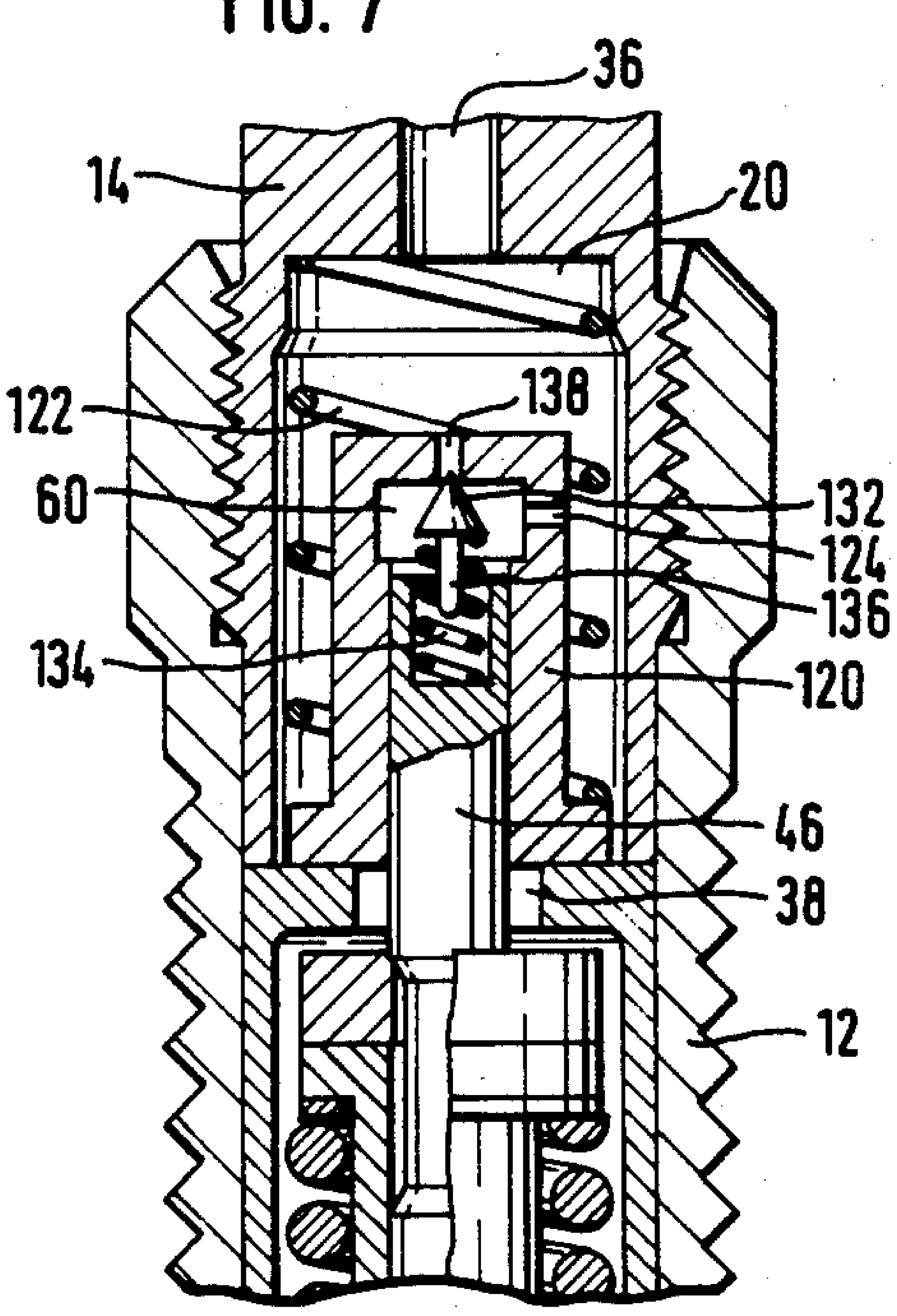


FIG. 7



FUEL INJECTION NOZZLE FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

The invention is based on a fuel injection nozzle for internal combustion engines having a valve needle stressed by a closing spring and opening in the flow direction of the fuel, the valve needle being connected with a piston which defines a damping chamber filled with fuel, which damping chamber communicates only via a throttle conduit with the flow path of the fuel during the opening stroke of the valve needle. In such injection nozzles, the opening movement of the valve needle is delayed or damped, at least over a portion of its stroke, in that the fuel is capable of flowing into the damping chamber or exiting from this chamber only in a throttled manner; the damping chamber at such a time is becoming larger or smaller. During the closing stroke of the valve needle, care must be taken that the valve needle is capable of returning rapidly to its closed position without being hindered by the damping means. In a known injection nozzle of this general type (German patent application 31 20 060), this is attained in that the piston is coupled with a valve needle via a drag connection, and this connection is interrupted during the return stroke of the valve needle, permitting the piston to return to its outset position under the influence of its own restoring spring. The damping chamber is embodied by a blind bore in the nozzle holder in which the piston is displaceably supported with a clearly-defined radial play. In this embodiment the piston represents an added part, and its return spring requires additional space in the axial direction of the injection nozzle. The drag connection between the valve needle and the piston requires a sufficiently large amount of radial play so that the piston will not stick against the bore wall of the nozzle holder and hinder satisfactory operation of the valve needle. Attaching the drag connection is furthermore associated with wear.

OBJECT AND SUMMARY OF THE INVENTION

The apparatus according to the invention has the advantage over the prior art that the cap forming the damping chamber is centered directly on the piston in the radial direction, so that a sufficiently large radial play is provided between the cap and the walls of the nozzle holder surrounding it, and jamming of the elements can thereby be reliably avoided. The piston can therefore be connected in one piece at least with the support disk serving to engage the closing spring, or if a supplementary damping effected by the forces of mass is not desired, then the piston is preferably also embodied by the valve needle itself or by the end portion thereof remote from the injection port. In either case, a separate part is not required for forming the piston, and a drag connection between the valve needle and the piston can also be eliminated. By means of the cap which is integrated within the volume of the pressure chamber, a volumetric compression caused by piston action which would influence the supply flow of fuel is avoided.

A particularly simple realization is attained if the cap in its entirety is pressed by a restoring spring against the end of the piston. Upon the return stroke of the valve needle, the entire cap is pressed back by the piston via the fuel cushion in the damping chamber; the restoring spring acting upon the cap thereupon positively displaces the quantity of fuel which had flowed into the damping chamber during the opening stroke back out of the damping chamber. This process can last until the beginning of the next opening stroke of the valve needle, so that the restoring spring acting upon the cap may be correspondingly weak in dimension.

A realization which hardly restricts the closing force during the return stroke of the valve needle is attained if the wall section of the cap which can be deflected counter to the spring force forms a valve body, which is displaceable outward, opening the damping chamber, relative to a rigid wall section having the valve opening. The valve body may preferably be embodied by the entire bottom of the cap, which is elastically deflectable with respect to the annular jacket portion of the cap.

The throttle conduit leading into the damping chamber may be embodied, in the simplest case, by the radial play between the piston and the overlapping portion of the cap. A realization which is less sensitive to becoming soiled is attained if the cap includes a throttle bore discharging into the damping chamber, the throttle bore being provided by way of example in the bottom of the cap.

For the sake of limiting the damped portion of the stroke of the valve needle, the cap may advantageously have at least one radial slit of a predetermined depth in its jacket portion. The magnitude of the axial overlapping of the radial slit or slits by the piston in the closing position of the valve needle then determines the length of the damped portion of the stroke upon opening of the needle. This control function can also be assumed by a transverse bore in the cap. The radial slit in that case assures only the unthrottled flow of fuel through the pressure chamber.

It is particularly advantageous if the cap is supported, toward the injection opening, via a prestressed support spring on the housing. By appropriately adapting the support spring to the damping coefficient, the damping can be limited in a pressure-dependent manner. This is desirable in some cases in the high rpm range of the engine, in order that the restoring spring will be able to return the cap back to its outset position by the beginning of the next injection process.

In an apparatus having a support spring, the assembly of the elements is made easier if the restoring spring for the cap engages a cage which is displaceably supported between two stops attached to the housing and in which the cap and the support spring are held.

Another possibility for limiting the damping effect in accordance with pressure is described, in which the cap is provided with a throttle valve opening toward the damping chamber; the throttle valve is controlled by the difference between the fuel pressures outside and inside the damping chamber.

A more compact realization of the injection nozzle is attained if the cap is provided with a flange, which is engaged by the restoring spring of the cap, here embodied as a helical spring. In that case, the restoring spring extends over the cap and a portion of the piston, so that space in the axial direction of the injection nozzle is not required for this portion of the restoring spring.

A particularly simple embodiment is attained if the piston is connected in one piece with the valve needle or is embodied by the valve needle itself. In some cases, however, it may also be efficacious to connect the piston in one piece with a support member for the closing spring of the valve needle.

The invention will be better understood and further objects and advantages thereof will become more apparent from the ensuing detailed description of seven preferred embodiments taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a cross-sectional view of an injection nozzle in accordance with the first exemplary embodiment of the invention, seen in longitudinal section; and

FIGS. 2–7 show the other exemplary embodiments, each being illustrated by a fragmentary cross-sectional view taken through a portion of the apparatus of particular pertinence.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The injection nozzle of FIG. **1** has a nozzle body **10**, which is firmly clamped to a nozzle holder **14** by a sleeve nut **12**. A sheath **16** is disposed between the nozzle body **10** and the nozzle holder **14**, and the sheath **16** has an inwardly directed shoulder **18** which divides a chamber **20** from a chamber **22** of larger diameter in the interior of the injection nozzle. A valve seat **24** is formed in the nozzle body **10**, and a valve needle **26** which is displaceably disposed, has its sealing cone **27** pressed by a closing spring **28** against the valve seat **24**. The closing spring **28** is supported on the nozzle body **10** and via a flange element **30** engages a support disk **32**, which is supported in turn on a shoulder **34** of the valve needle **26**.

An inlet bore **36** is formed in the nozzle holder **14** and discharges into the chamber **20** which communicates via an aperture **38** surrounding the shoulder **18** with the chamber **22**. A bore **40** in the nozzle body leads out of the chamber **22** into an annular chamber **42**, which is formed between the central bore wall of the nozzle body **10** and the jacket circumference of a section **44** of smaller diameter of the valve needle **26** and extends to a point just before the valve seat **24**. A distance h_g exists between the flange element **30** and the nozzle body **10** in the illustrated closing position, this distance corresponding to the total stroke of the valve needle **26**. The valve needle **26** is displaced outward, in the opening direction, by the fuel pressure counter to the force of the closing spring **28** until the flange element **30** strikes against the nozzle body **10**. Upon the closure of the valve, the closing spring **28** returns the valve needle **26** back inward, into the illustrated closed position.

A piston-like extension **46** which is integral with the shoulder **34** of the valve needle **26**, passes through the aperture **38** and protrudes into the chamber **20**. The diameter of the piston-like extension **46** corresponds to the guide diameter of the valve needle **26**. A cap **48** is placed upon the extension **46** and has a bottom **50**, a jacket portion **52**, and a flanged rim **54**. The cap **48** is engaged by a restoring spring **56**, which surrounds the jacket portion **52** and presses the flange rim **54** against the shoulder **18** of the sheath **16**.

Transverse slits **58** are provided in the flanged rim **54** and a region adjacent thereto of the jacket portion **52** of the cap **48**, and when the valve needle **26** is opened the fuel can flow through these transverse slits **58** out of the chamber **20** into the chamber **22**. In the illustrated closed position of the valve needle **26**, a damping chamber **60** is formed between the end face of the extension **46** and the inner bottom wall **50** of the cap **48**, the damping chamber communicating in a throttled manner, via the radial play between the extension **46** and the jacket portion **52** of the cap **48**, with the flow path of the fuel. In the illustrated closed position, the extension **46** overlaps the transverse slits **58** and the cap **48** in the axial direction by the distance h_v, which corresponds to the damped pre-stroke of the valve needle **26** to be described below.

The illustrated injection nozzle functions as follows:

The increasing fuel pressure at the onset of an injection procedure creates a pressure difference between the throttled damping chamber **60** and the chamber **20**, because the cap **48** is not capable of following the movement of the valve needle **26**. The pressure increase in the damping chamber **60** and thus on the end face of the extension **46** or of the valve needle **26** is effected more slowly than in the chamber **20**, so that the movement of the valve needle **26** is delayed or damped until the valve needle **26** has traveled the distance h_v and the end face of the extension **46** arrives in the vicinity of the transverse slits **58**. From then on, the remaining stroke of the valve needle is effected in an undamped manner until the flange element **30** strikes the nozzle body **10**.

During the first stroke portion h_v, fuel is expressed into the damping chamber **60** by the radial play existing between the extension **46** and the jacket portion **52** of the cap **48**. During the closing movement of the valve needle **26**, the cap **48** is carried along upward as well via the cushion of fuel that has flowed into the damping chamber **60**; the restoring spring **56** is then capable of exerting only a relatively slight resistance to the substantially stronger closing spring **28**. The restoring spring **56** is dimensioned such that the quantity of fuel that has flowed into the damping chamber **60** is positively displaced out of the damping chamber **60**, except for a remnant volume, between the beginning of the closing stroke of the valve needle **26** and the beginning of the next opening stroke, and the cap **48** has again come to rest on the shoulder **18**.

The cap **48** is centered on the valve needle **26** and otherwise has a sufficiently large radial play with respect to the nozzle holder **14**, so that the valve needle **26** can operate without jamming. The restoring spring **56** for the cap **48** extends partway over the cap **48**, so that in this construction the means for partial damping of the opening stroke of the valve needle **26** require little space in the axial direction of the injection nozzle.

The injection nozzle of FIG. **2** agrees substantially with the injection nozzle of FIG. **1** described above, so that identical elements will also be identified by the same reference numerals. However, the cap **48** is provided with a throttle bore **62** in its bottom **50**, with which throttle bore **62** the effectiveness of the piston damping is affected. The extension **46** of the valve needle **26** is also extended upward as compared with the design shown in FIG. **1**, it being so long that the cap **48** can no longer be seated on the shoulder **18**, but instead is at a distance h_l from the shoulder **18** in the closing position of the valve needle **26**. As a result it is attained that the means for damping the valve needle movement come into effect only after a pre-stroke of the dimension h_l has been executed, which in some cases may be advantageous. The upper end of the extension **46** of the valve needle **26** is rounded in embodiment, because here the cap **48** is supported, in the illustrated outset position, directly on top of the valve needle **26** or on its extension **46**, and the rounded contour makes it easier to positively displace the fuel from the damping chamber **60**.

In the exemplary embodiments of FIGS. **1** and **2**, the cap **48** represents a rigid, integral element, which is moved in its entirety back and forth by the valve needle **26** and the restoring spring **56**. In the injection nozzle shown in FIG. **3**, instead of a one-piece cap, a combination of an annular body **64** and a flat valve body **66** is provided, which is pressed by a closing spring **68** against the upper end face of the annular body **64**. The annular body **64**, in the illustrated closing position of the valve needle **26**, is supported on the shoulder **18** of the sheath **16** and is dimensioned such that in this position a small remnant volume of the damping chamber **60** remains. Upon the movement of the valve needle **26** in the opening direction, fuel is positively displaced into the damping chamber **60** via a throttle bore **70** in the valve body **66**.

The desired, damped pressure increase exerted upon the end face of the extension **46** of the valve needle **26** is thereby generated. Once the valve needle **26** has executed the stroke portion h_v, the end face of the extension **46** enters the region of a transverse slit **72** of the annular body **64**, whereupon the damping is eliminated. Upon the return stroke of the valve needle **26**, the valve body **66** lifts away from the annular body **64**, so that the fuel previously displaced into the damping chamber can exit from the damping chamber **60** once again, except for the remnant volume.

In the injection nozzle of FIG. **4** a damping piston **76** is provided, which has a pedestal **78** serving as a support member for the closing spring **28**. A cap **80** is placed onto the damping piston **76**, its bottom **81** being pressed by a restoring spring **82** against a central extension **84** of the damping piston **76**. The cap **80** is likewise provided with transverse slits **86** and is realized with a length such that in the illustrated closing position of the valve needle it is at a distance h_l from the shoulder **18** of the sheath **16**. The processes of opening and closing of the valve take place in the same manner as in the above-described exemplary embodiments. Embodying the damping piston **76** as a separate part from the valve needle **26** has the advantage that the diameter of the damping piston **76** can be selected as larger than that of the valve needle **26**, so that the damping effect can also be influenced in the desired manner.

In all four exemplary embodiments described above, the damping chamber **60** could be opened toward the pressure chamber **20** by means of one or more additional bores in the cap **48**, **80** or in the annular body **64**, instead of by way of the transverse slits **58**, **72**, **86**.

In the injection nozzle of FIG. **5**, a cap **90** is placed onto the extension **46** of the valve needle **26**, the cap **90** having a flanged rim **92** at its upper end which is engaged by a support spring **94**. The cap **90** and the support spring **94** are held in a cage **96**, which is displaceably supported with a notable amount of radial play in the chamber **20** between a shoulder **98** of the nozzle holder **14** and the shoulder **18** of the sheath **16**. A restoring spring **100** acts upon the cage **96**, forcing the cage **96** toward the shoulder **18**. The cage **96** is provided with apertures **102**, **104**, **116**, **108** in its wall, through which the fuel flows out of the chamber **20** into the aperture **38** and the chamber **22**. As in the above-described embodiments, the damping chamber **60** is provided in the cap **90**, communicating via a throttle bore **110** with the chamber **20**.

The injection nozzle according to FIG. **5** functions as follows:

At the beginning of an injection procedure, the elements assume the position shown in FIG. **5**, in which the cage **96** is resting on the shoulder **18**. With increasing fuel pressure, a pressure difference between the damping chamber **60** and the chamber **20** is created, the cap **90** under the influence of the support spring **94** cannot at first follow the movement of the valve needle **26**, and the fuel passes via the narrow throttle bore **110** into the damping chamber **60** in a delayed fashion. The pressure difference is the greater, the more rapidly the valve needle **26** moves in the opening direction. The support spring **96** is designed such that in idling and at a medium rpm range of the engine, the pressure difference is not capable of overcoming the pre-stressing of the support spring **94**, so that the damping is effective over the entire needle stroke. If needed, the cap **90** could be provided with slits, similarly to the realization of FIG. **1**, so that with a long needle stroke, a stroke-dependent limitation of the damping is produced.

In the upper rpm range of the engine, the pressure difference between the chamber **20** and the damping chamber **60** increases to such an extent that the pre-stressing force of the support spring **94** is overcome. The cap **90** then follows the valve needle **26**, the support spring **94** becoming compressed; as a result the damping effect is no longer amplified. By appropriate selection or adjustment of the support spring **94**, the damping effect can be limited in accordance with pressure to a desired extent. Upon the closing stroke of the valve needle **26**, at first the entire cage **96** together with the cap **90** and support spring **94** is deflected upward, the restoring spring **100** becoming compressed. The restoring spring **100** is dimensioned such that it expresses the fuel which has flowed into the damping chamber **60** from the beginning of the closing stroke of the valve needle **26** to the beginning of the next opening stroke back out of the damping chamber **60** except for the remnant volume corresponding to the illustrated outset position, and has returned the cage **96** back to where it rests on the shoulder **18**.

In the injection nozzle shown in FIG. **6**, a cap **120** is placed onto the extension **46** of the valve needle **26**, the cap **120** being pressed toward the shoulder **18** of the sheath **16** by a restoring spring **122**. A damping chamber **60** is again provided in the cap **120**, communicating via a throttle bore **124** and additionally via a throttle valve **126** opening toward the damping chamber **60** with the chamber **20**. The throttle valve **126** has a closing member **128**, which is pressed against its seat by means of a leaf spring **130** disposed outside the damping chamber **60**. The leaf spring **130** is dimensioned and pre-stressed such that the throttle valve **126** opens at a predetermined pressure difference and limits the damping effect to a predetermined value. Upon the closing stroke of the valve needle **26**, the throttle valve **126** is closed; the cap **120** again is deflected temporarily upward, as in the constructions shown in FIGS. **1–4**, so that the closing stroke of the valve needle **26** is either unhindered by the escape of fuel from the damping chamber **60** or is not substantially hindered thereby.

The injection nozzle of FIG. **7** functions like that of FIG. **6**; however, a throttle valve **132** is provided here, the closing spring **134** of which, embodied as a helical spring, is disposed in the interior of the cap **120**. The throttle valve **132** has a closing member **136**, which closes a relatively small bore **138** in the bottom of the cap **120**, so that the closing spring **134** may be very small in size, and can be accommodated in a blind bore in the extension **46**.

The foregoing relates to preferred exemplary embodiments of the invention, it being understood that other embodiments and variants thereof are possible within the spirit and scope of the invention, the latter being defined by the appended claims.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A fuel injection nozzle for internal combustion engines provided with a valve needle stressed by a closing spring and arranged to open in a fuel flow direction, said valve needle further being connected with a piston associated with a damping chamber filled with fuel, said damping chamber arranged to communicate and expand only via a throttle conduit with a flow path of the fuel during an opening stroke of the valve needle, characterized in that said damping chamber is provided by a cap mounted on said piston, said cap further being supported at least after a pre-stroke (h_1) of said piston in an injection direction, said cap further having a wall section movable in an opposite direction thereto counter to the force of a restoring spring, said piston having an end face and said cap being urged toward said end face of said piston by said restoring spring, and said movable wall section defining a bottom portion of said cap.

2. An injection nozzle as defined by claim **1**, characterized in that said movable wall section of said cap forms a valve body having a valve opening, said valve body further having a portion which is arranged to be displaced outwardly thereby opening said damping chamber.

3. An injection nozzle as defined by claim **1**, characterized in that said cap further includes an annular jacket portion and that said bottom of said cap can be lifted from said jacket portion counter to spring force.

4. An injection nozzle as defined by claim **1**, characterized in that said cap has at least one radial slit of predetermined depth in said jacket portion.

5. An injection nozzle as defined by claim **1**, characterized in that said cap is supported on a means via a pre-stressed support spring.

6. An injection nozzle as defined by claim **5**, characterized in that said cap is enshrouded by a cage means, said cage means displaceably supported between two stop means, and further wherein said pre-stressed support spring is held in said cage means.

7. An injection nozzle as defined by claim **1**, characterized in that said cap further includes a throttle valve arranged to open toward said damping chamber and said throttle valve further controlled by the pressure differences existing between the fuel inside and outside of said damping chamber.

8. An injection nozzle as defined by claim **1**, characterized in that said cap further includes a flange, which is engaged by said restoring spring and said restoring spring is helical.

9. An injection nozzle as defined by claim **1**, characterized in that said piston is integral with said valve needle.

10. An injection nozzle as defined by claim **1**, characterized in that said piston is associated with a support member and said support member adapted to receive the force of said closing spring of said valve needle.

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